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13AUG03 E829668-1 C12751
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1/77

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1. Your reference
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12 AUG 2003

2. Patent application number
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0318892.7

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*
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LONDON
SE3 0RL.

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation
399193 2001
8691834001

4. Title of the invention
STEREOSCOPIC IMAGING DEVICE AND MACHINE FOR FABRICATION THEREOF

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent
(including the postcode)

~~BIRCH TREE HOUSE~~
~~THE STREET~~
~~PETHAM KENT~~
~~CT4 5QU~~

see s177

Elkington + Fife LLP
Prospect House
8 Pembroke Road
Sevenoaks
Kent TN13 1XR.

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6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
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Continuation sheets of this form	0
Description	6
Claim *(s)*	2
Abstract	1
Drawing *(s)*	15+15

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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination and search *(Patents Form 9/77)*

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] [signature] Date 27/07/03 8/8/03

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STEREOSCOPIC IMAGING DEVICE AND MACHINE FOR FABRICATION THEREOF

The invention relates to a stereoscopic imaging device of the type that includes a spatially or temporally multiplexed screen, hereinafter referred to as a 'stereoscopic conversion screen', placed permanently or temporarily in front of a spatially or temporally modified image from a cathode ray tube, LCD, TFT, back-projection or other visual display unit. Also described is a machine for producing a suitable stereoscopic conversion screen for one embodiment.

Spatially multiplexed stereoscopic imaging devices are well-known but suffer from the disadvantage that although the central viewing area provides an acceptable stereoscopic effect, to the left and right of the centre, inversion of left and right stereoscopic images appears together with a vertical banding effect. The problem is caused at least in part by the difference in viewing positions of the left and right eye. This may be corrected if images corresponding to different stereoscopic views are placed on successive horizontal rows, rather than in vertical strips, as is normal practice.

In the established art, direction of light from the image to the appropriate observational point is achieved either by means of a mask that absorbs light that would otherwise reach an observer inappropriately, or by means of a lens array that refracts light in the appropriate directions.

A masking arrangement suffers from the shortcoming that as a larger number of viewing positions are required, the observed stereoscopic image becomes dimmer. The lens array approach is difficult to apply in a way that will both overcome the aforementioned inversion and banding effects and also allow multiple-observer viewing. Also, fabrication of such lens sheets causes problems due to the complexity of the optical surface required. A structure for readily fabricating such lens sheets is described.

However, a preferred embodiment of the invention uses optical light-guides, which channel light in the appropriate directions from the image to the observer(s). These may be solid and of optically transparent material, preferably coated with a material of lower refractive index, or hollow, preferably with reflective boundaries.

A special machine is described to readily fabricate one form of stereoscopic conversion screen for the light guide embodiment of the invention. In this form, the conversion screen comprises numerous accurately positioned and inclined holes through suitable sheet material. These holes only allow light to pass in the correct directions.

Rows of holes are produced by numerous piercing pins, hole cutting dies or fibre-optic outlets carrying coherent light, fitted directly or otherwise to one or more sliding shuttles that can be moved intermittently. A shuttle is constrained to move in a precisely set direction by a channelled guide. This channelled guide has a simple or compound pivot so that it can be inclined at chosen angles to the material to be pierced and thereby ensure that holes are pierced at a desired angle to the surface of the material and in a precise location. For example, the channelled guide may have its angle changed after each row of holes is produced, as a result of which the angles of inclination of the holes can be accurately changed in a pre-determined manner with position.

Control over the angle of the channelled guide may be by means of a screw mechanism or otherwise, driven manually, electrically, pneumatically, hydraulically or otherwise.

If neighbouring holes in a row are to have differing inclinations, these may vary in the same plane perpendicular to the surface of the material to be pierced or in a varying plane perpendicular to that surface. For the first case, the position of the channelled guide pivot may be changed for successive piercing runs with differently located piercing-pins. For the second case, the angles at which the individual piercing pins, hole cutting dies or fibre optic outlets are set may be varied.

Temporally multiplexed stereoscopic imaging devices are also well known, but usually employ a switch-able mask such as an LCD mask for their stereoscopic conversion screen. The observed image brightness is then inversely proportional to the number of stereoscopic views required. In a preferred embodiment of the present device the stereoscopic conversion screen comprises a multiplicity of electrostatically or electromagnetically driven light-guides, which may be of microscopic or molecular dimensions. In this way light is correctly directed from the image to any number of observation positions without a corresponding reduction in observed brightness.

For a temporally multiplexed stereoscopic imaging device, the images have to be presented very rapidly and if colour display devices are not available for such fast rates, coloured TFT or LCD screens placed in front of a monochrome display may be used to colourise such an image.

It is preferable to place opaque strips at the left and right margins of the image to avoid loss of stereoscopic vision in those regions and to enhance the effect of depth.

An arrangement for the stereoscopic imaging device to be removable from the image is described.

Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 shows an underlying cause of lateral inversion as due to optical looming of the stereoscopic conversion screen in relation to the image.

FIGURE 2 shows the asymmetrical looming that occurs with respect to the left and right eyes.

FIGURE 3a shows a laminated structure for light-guides, that will allow correction for asymmetrical looming by virtue of differences between the optical directional properties of successive laminations.

FIGURE 3b shows a corrugated reflective foil form of optical light-guide for an individual lamination.

FIGURE 3c shows a solid refractive form of optical light-guide for an individual lamination.

FIGURE 4 shows a multi-holed light-guide stereoscopic conversion screen.

FIGURE 5 shows a full view of a preferred embodiment of the machine for fabrication of a multi-hole stereoscopic conversion screen.

FIGURE 6 shows a detail of a pin holding block assembly from the machine for fabrication of a multi-hole stereoscopic conversion screen.

FIGURE 7 shows a detailed view of one form of macroscopic cell for a dynamic light-guide.

FIGURE 8 shows the sequence in which a cell of dynamic light-guides may be electrostatically or electromagnetically switched.

FIGURE 9 shows a cell of microscopic dynamic light-guides.

FIGURE 10 shows a cell of molecular dynamic light-guides.

FIGURE 11 shows the positioning of a colourising screen in front of a monochrome image.

FIGURE 12 shows the positioning of vertical opaque strips placed at the left and right edges of the image display, a small distance in front of the underlying image.

FIGURE 13 shows a preferred way in which the stereoscopic conversion screen assembly may be portably located in front of the underlying television or video image.

As shown in Figure 1, from a single viewing point 3, the stereoscopic conversion screen 2 appears to be wider in comparison to the image 1 than it actually is, an effect known as optical looming. Because both the image 1 and stereoscopic conversion screen 2 are geometrically vertical strips, there will be a loss of phasing between the strips of each. If the screen 2 is made slightly smaller than the image 1, this effect can be corrected.

However, as shown in Figure 2, the different viewing positions of the left eye 6 and right eye 7 give rise to asymmetrical looming. The stereoscopic conversion layer 2 and image 1 have to be displaced relative to each other since the image centre line 5 and stereoscopic conversion screen centre line 4 do not coincide. By modifying the spacing and width of the mask elements, lens elements or light-guide elements the adverse effects of stereo inversion and vertical banding can be removed, different stereoscopic images being presented on consecutive horizontal rows of image elements.

The light from the image to the observer may be directed by an array of lenses or prisms. A laminated mode of construction will then ensure that the manufacture is feasible.

In the preferred embodiment of this invention, as shown in Figures 3a, 3b, 3c and 4 light from the image to the observer may be directed by the stereoscopic conversion screen 2 using optical light-guides 8. Stereoscopic images for a number of different views are multiplexed over a number of consecutive horizontal lines. Figure 3a shows a laminated construction suitable for easy fabrication. Figure 3b shows a light-guide lamination in which the boundaries are made from a reflective foil that is corrugated. Figure 3c shows a solid transparent light-guide lamination. The lateral undulations reduce horizontal light scattering and associated loss of horizontal resolution. Such a lamination should be coated with a substance with lower refractive index, in order to achieve total internal reflection. This substance may be an adhesive that holds the stack of laminations together.

Figure 4 shows a preferred stereoscopic conversion screen comprising a suitable sheet material, possibly laminated metal foil, for example loosely packed aluminium foil, pierced with holes that may correspond to each picture element. The direction of these holes is such as to allow light from the image to only travel in the correct direction to the observer(s). In order to add strength to the pierced sheet, it may, after piercing be impregnated with a liquid that sets to a transparent solid. For example clear varnish may be used. The sheet may alternatively be transparent and the transparent liquid that is added after piercing should then have a higher refractive index upon setting, in order to achieve total internal reflection.

One embodiment of a machine for the fabrication of multi hole stereoscopic conversion screens will now be described. As seen in Figure 5, a robust base plate 9 carrying the material to be pierced 10 and support frame 11 are required to prevent unwanted internal movement of the machine during use. A shuttle 12 is free to move in vertical orientations in a channelled guide 13. The channelled guide 13 is re-enforced by tie bars 14. The channelled guide 13 rotates about an axle 15 secured by collars 16. The axle 15 passes through an axle support bar 17 attached to the support frame 11. The lower edge of the shuttle 12 carries a pin holding block 18 firmly holding hole-piercing pins. The lowest extremity of the pin holding block has an elastic edging 19, as shown in detail in Figure 6. The elastic edging 19 ensures that the material 10 is held down whilst the pins 20 are piercing and whilst they are being released.

To accurately produce a row of holes of a set inclination, the shuttle 12 is lowered. To obtain the next row of holes of different, inclination of the channelled guide 13 is changed, by rotating control wheel 21. This causes studding 22 to rotate and as it passes through the screwed idling block 23, to move the channelled guide 13, rotating it about the axle 15. The screw studding has clearance on each of the studding supports 24. For additional stability a guide rod 25 is present, parallel to the screw studding and fixed to guide rod supports 26.

A macroscopic form of dynamic light-guide stereoscopic conversion screen is shown in Figure 7. The light-guide assembly is placed between faceplates distal 27 and proximal 28 to the observer(s) and in front of the image. The light-guides make use of thin strips of conducting foil 29 that are pivoted along one edge 31 and free to move at the opposite edge. The pivoted edge is electrically connected, while the free end moves near to transparent conducting strips 30 that run parallel to the free edge. Transparent spacers 32 and links 33 are present to add mechanical stability to the assembly. For electrostatic movement of the strips 29, the voltage polarities of the strips 29 and the transparent conducting strips 30 are changed in sequence, as indicated in Figure 8, and by electrostatic attraction and repulsion the conducting foil strips 29 caused to deflect to left and right, causing light rays from the image to be suitably deflected. Similarly, for electromagnetic switching, the electrical current directions though the conducting foil strips 29 and transparent conducting strips 30 are changed in sequence and by electromagnetic attraction and repulsion the conducting foil strips 29 caused to deflect to left and right. The reflective surfaces of the conducting foil strips 29 act as light-guide boundaries that cause light to be guided in a required direction.

A problem with the macroscopic moving light-guide stereoscopic conversion screen of the previous paragraph is that the mass of the light-guide boundaries will prevent sufficiently rapid movement in some applications. Figure 9 shows microscopic light-guide boundaries 34 to reduce inertial problems. In this case, the light-guides or light-guide boundaries might be conducting or magnetic fibres of suitable cross section and with the required reflective or refractive properties. These will move in response to electrostatic forces due to changing voltages on or electromagnetic forces due to changing electrical currents through the neighbouring transparent conducting strips 35.

The moving light-guides or light-guide boundaries may also be elongated molecules 36 as shown in Figure 10. Such molecules have permanent or temporary electrostatic dipoles, or magnetic properties, such that they will respond to changing voltages on or electrical currents in the neighbouring transparent conducting strips 35.

Such temporally multiplexed embodiments of the invention may require that the images corresponding to different views of the original scene or object be presented at a high rate. Only monochrome displays may be available to provide such high refresh rates. If so, as shown in Figure 11, a coloured LCD or TFT screen 37 placed in front of the stereoscopic conversion screen 2 can be used to provide colours in the appropriate areas. Indeed such a colourising screen may be used for any monochromatic image.

As shown in Figure 12 in order to avoid loss of stereoscopic vision at the left and right margins of the image 1 and stereoscopic conversion screen 2, vertical opaque strips 38 may be placed a small distance in front of at the left and right edges of the stereoscopic conversion screen 2. In this way, the extreme left and right image edges are obscured. This also produces an enhanced effect of depth.

In one embodiment of the invention, the stereoscopic conversion screen 2 may be taken away from the image 1 when a stereoscopic effect is not required as shown in Figure 13. The stereoscopic conversion screen assembly rests or hooks over the top of the image bezel 39 and its height and parallelism are adjusted if necessary by means of screws 40.

CLAIMS

1. A stereoscopic display device comprising a spatial or temporal multiplexing assembly and a suitably positioned synchronous underlying image constructed in such a way that a stereoscopic effect can be obtained across the full width of an image.
2. A stereoscopic display device as described in Claim 1 in which left and right or multiple views are presented on consecutive lines of the image and consecutive horizontal lines of the stereoscopic conversion screen are arranged to allow light from the image to pass to the appropriate eyes of the observer(s).
3. A stereoscopic display device as described in Claim 1 or Claim 2 in which the consecutive rows of the stereoscopic conversion screen have elements that are positioned so as to correct for their asymmetrical optical looming in relation to the image as seen by different observational positions.
4. A stereoscopic display device as described in Claim 1, Claim 2 or Claim 3 in which the stereoscopic conversion screen uses optical light-guides to direct light from the image into the correct directions for the image.
5. A laminated structure for a stereoscopic display device as described in Claims 1, 2, 3 and 4 for the static array of light-guides, lenses or prisms.
6. A stereoscopic display device as described in Claim 4 wherein the stereoscopic conversion screen comprises horizontal strips of corrugated transparent material wherein each corrugation only allows light to reach an observer from the correct image point.
7. A stereoscopic display device as described in Claim 4 wherein the stereoscopic conversion screen comprises horizontal strips of hollow corrugated reflective cells, each corrugation pointing in a direction so as to allow light only to reach an observer from the correct image point.
8. A stereoscopic display device as described in Claim 4 wherein the stereoscopic conversion screen is pierced with holes inclined at suitable angles to allow light to only travel in particular directions from the image to the observer(s).
9. A multiple hole-piercing machine comprising one or more channelled guides each with a simple or compound pivot and carrying a sliding shuttle equipped to produce rows of precisely positioned and inclined holes in suitable sheet material as required for the embodiment of the invention as described in claim 8.
10. A multiple hole-piercing machine as described in Claim 9 in which the angle of inclination of holes may be modified by rotating a sliding shuttle and channelled guide about its axle or compound support.
11. A multiple hole-piercing machine as described in Claim 9 in which the angle of inclination of holes may be modified by changing the position of the axle.
12. A multiple hole-piercing machine as described in Claim 9 in which the angle of inclination of holes may be modified by adjusting the orientation of individual piercing-pins, hole making dies or fibre optic outlets carrying coherent light.
13. A multiple hole-piercing machine as described in Claim 9 in which the angle of inclination of a shuttle and guided channel are controlled by a

screw mechanism or otherwise, manually, electrically, hydraulically, pneumatically or otherwise.

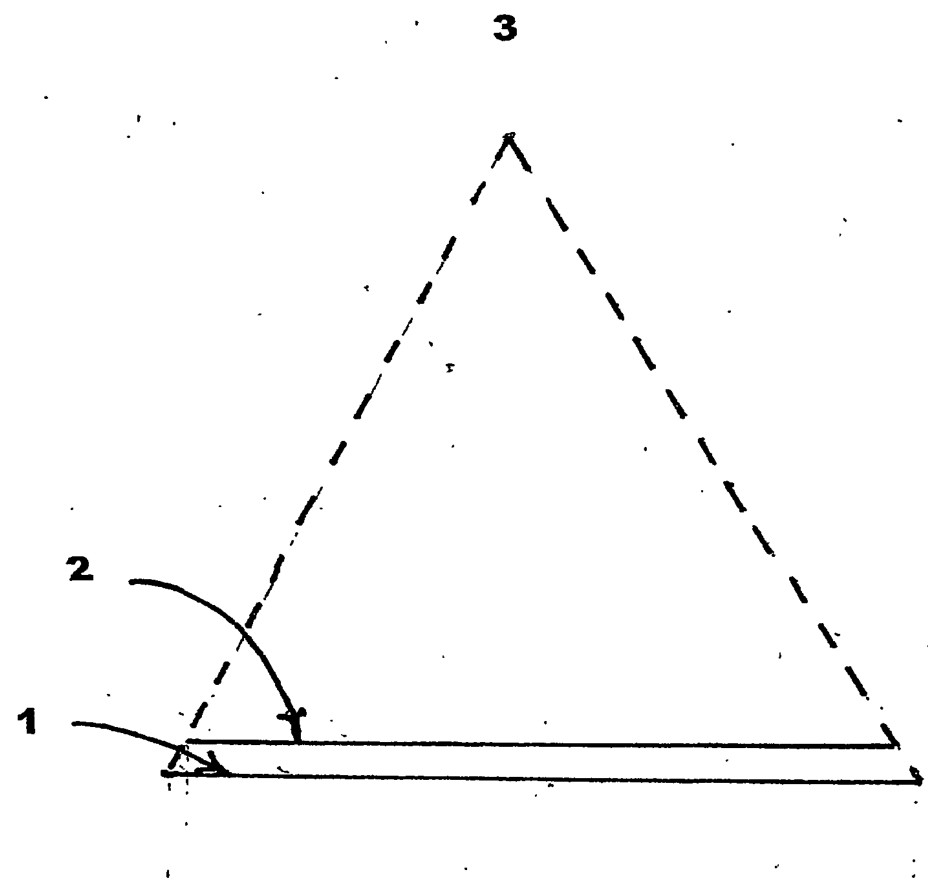
14. A multiple hole-piercing machine as described in Claims 9 to 13 in which the lower edge of the shuttle assembly carries an elastic edging to allow more controlled piercing and release of piercing pins or hole cutting dies.
15. A multiple hole-piercing machine as described in Claims 9 to 13 in which hole cutting is produced by coherent light carried to the correct locations of the lower edge of the shuttle assembly by fibre-optic cable or otherwise.
16. A temporally multiplexed stereoscopic display device as described in Claim 1 such that the stereoscopic conversion screen contains a multiplicity of dynamic light-guides electrostatically or electromagnetically controlled to correctly channel light from the image to observation points.
17. A stereoscopic display device as described in Claim 1 and Claim 16 wherein the light-guides have reflective boundaries that may be made of reflective foil.
18. A stereoscopic display device as described in Claim 1 and Claim 16 wherein the light-guides or their boundaries are microscopic fibres with suitable electrical, magnetic and optical properties.
19. A stereoscopic display device as described in Claim 1 and Claim 16 wherein the light-guides or their boundaries are molecules that have temporary or permanent dipoles or contain magnetic elements or groups.
20. A stereoscopic display device as described in Claims 1, 2 and 16 such that raised vertical strips in order to conceal the left and right vertical margins of the image or stereoscopic conversion screen prevent loss of stereoscopic vision and provide an enhanced impression of depth.
21. A stereoscopic display device as described in Claims 1, 2 and 16 such that its frame could be hung over the bezel of a suitable image in order to allow the stereoscopic device to be used when needed and removed otherwise.
22. A stereoscopic display device as described in Claim 21 such that the frame could be adjusted for height and parallelism if necessary for example by means of adjusting screws.

ABSTRACT

STEREOSCOPIC IMAGING DEVICE AND MACHINE FOR FABRICATION THEREOF

A stereoscopic display device in which the image presented to the device is temporally or spatially multiplexed. In one embodiment, light is passed in appropriate directions by static light-guides, masks, lenses or prisms compensating for stereoscopic inversion that would otherwise be caused by asymmetrical looming between observation points. A laminated construction may simplify fabrication. Light-guides preferably comprise numerous accurately placed and inclined perforations in a sheet of suitable material. A multiple hole-piercing machine for producing such perforations is described. In a second embodiment, dynamic light-guides or their boundaries are moved in phase with changes in stereoscopic image views, passing light in the correct direction at the correct instant. Movement is by means of electrostatic or electromagnetic forces produced by charges on or currents through these light –guides or their boundaries and adjacent transparent electrodes. Such light-guides or their boundaries may be of microscopic or molecular size.

Figure 1



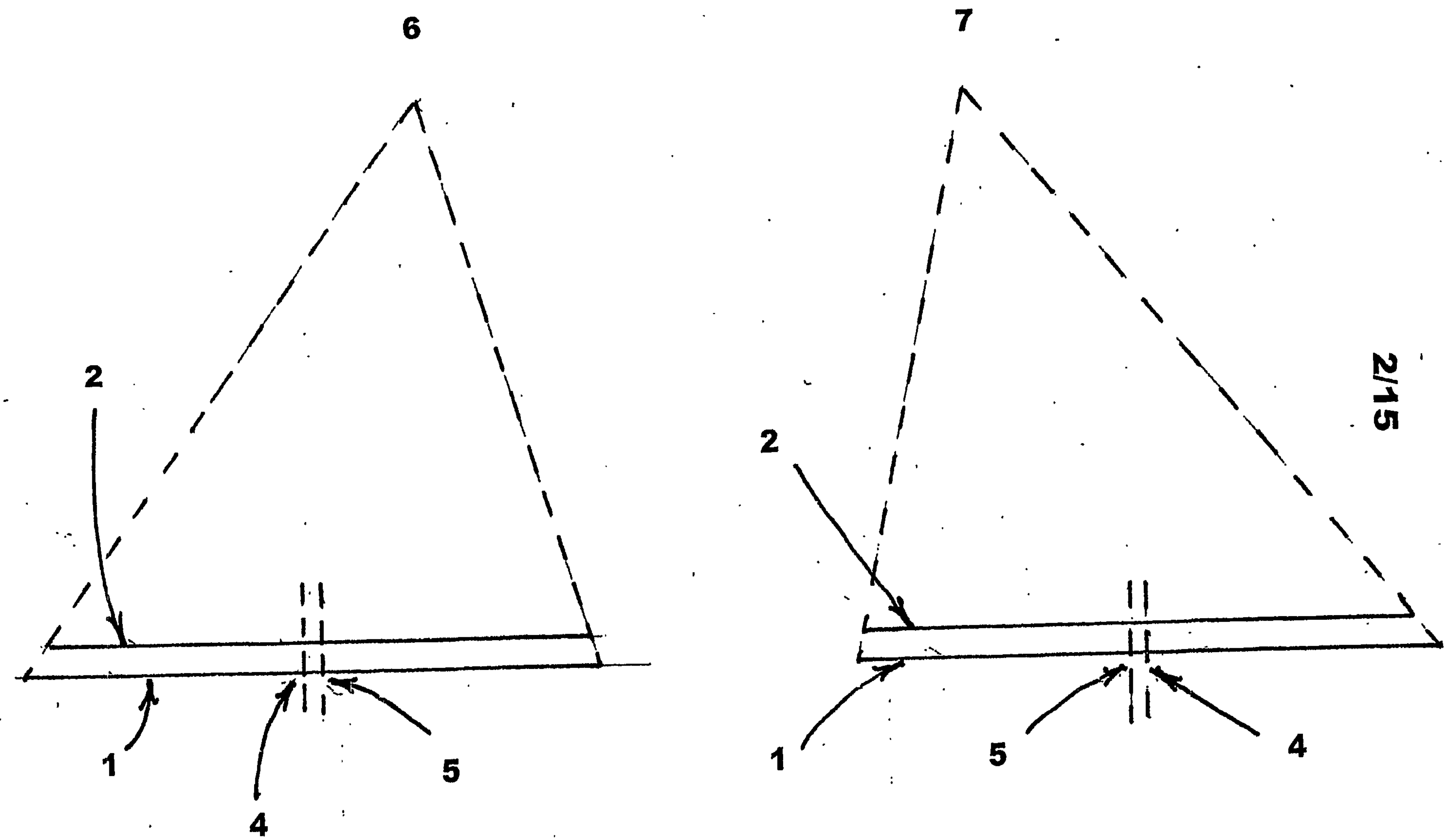
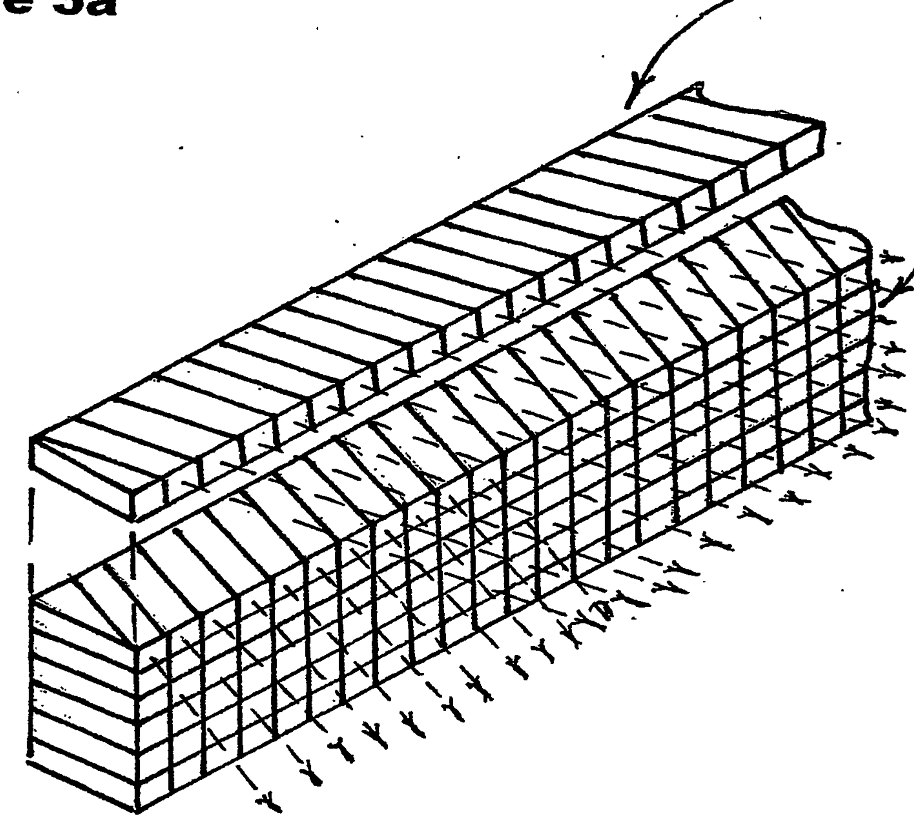


Figure 2

Figure 3a



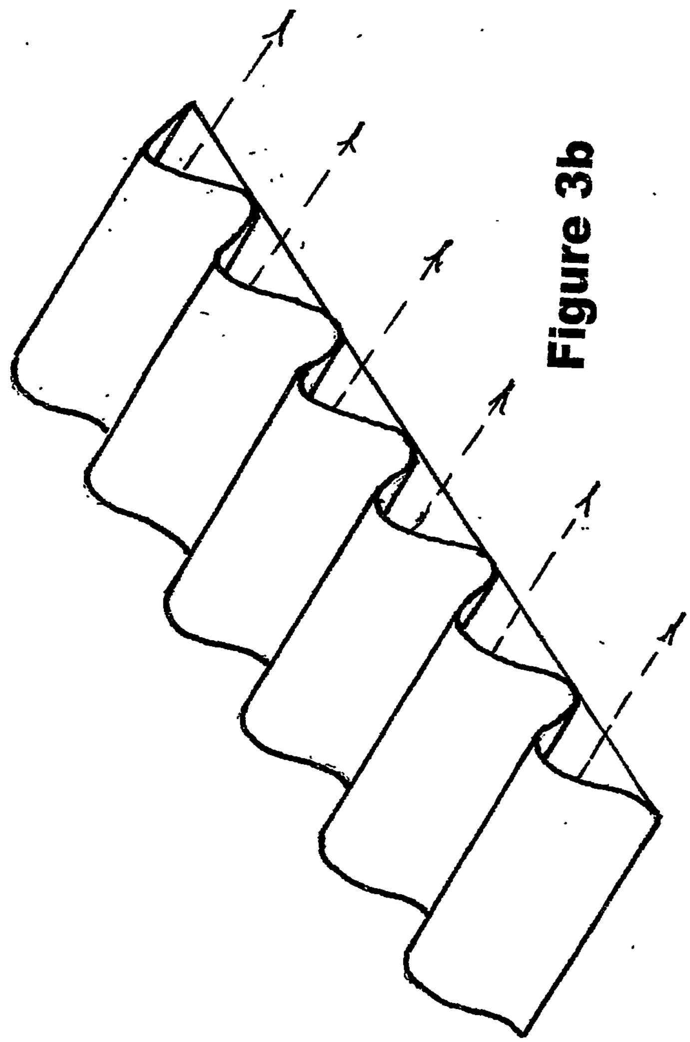


Figure 3b

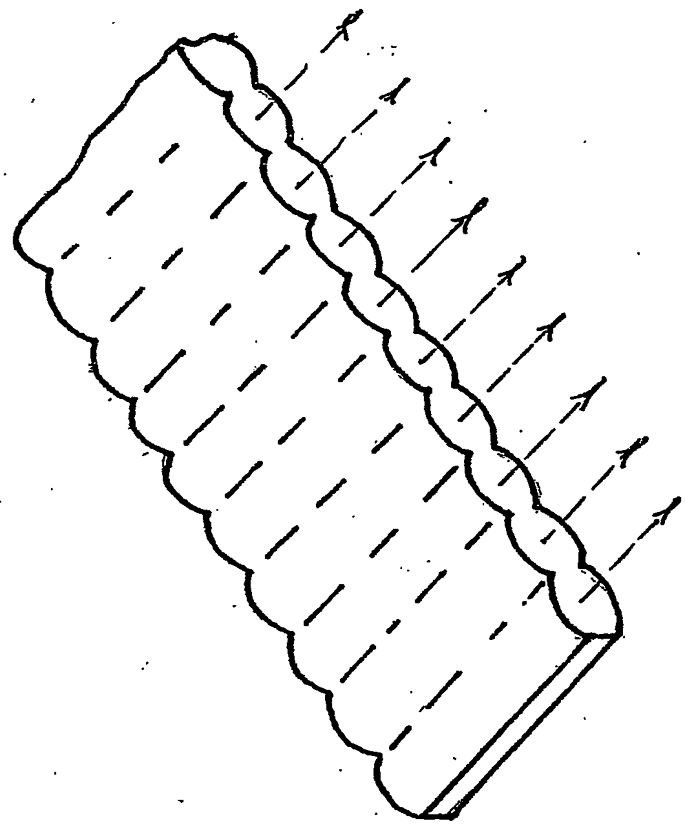


Figure 3c

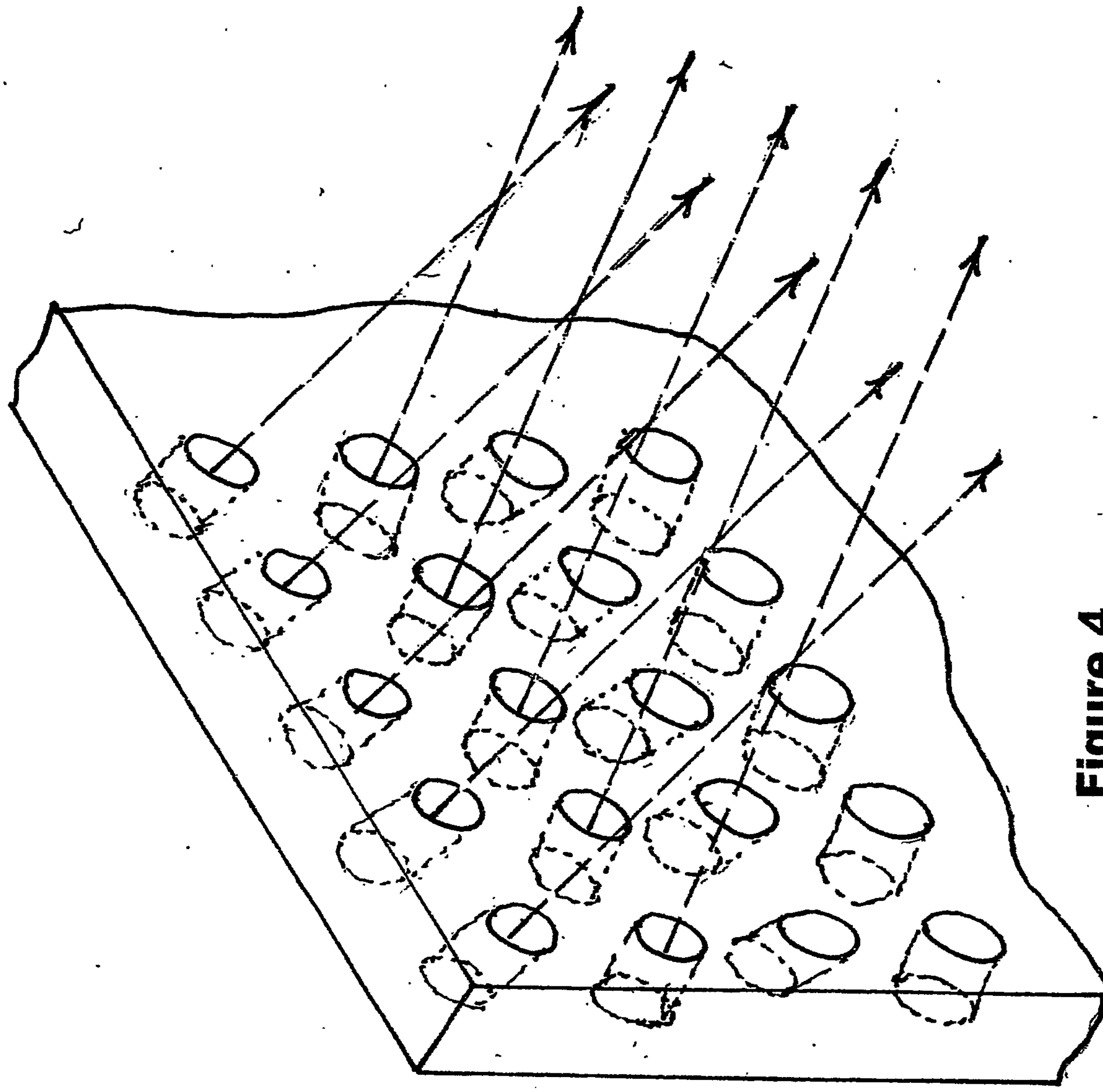
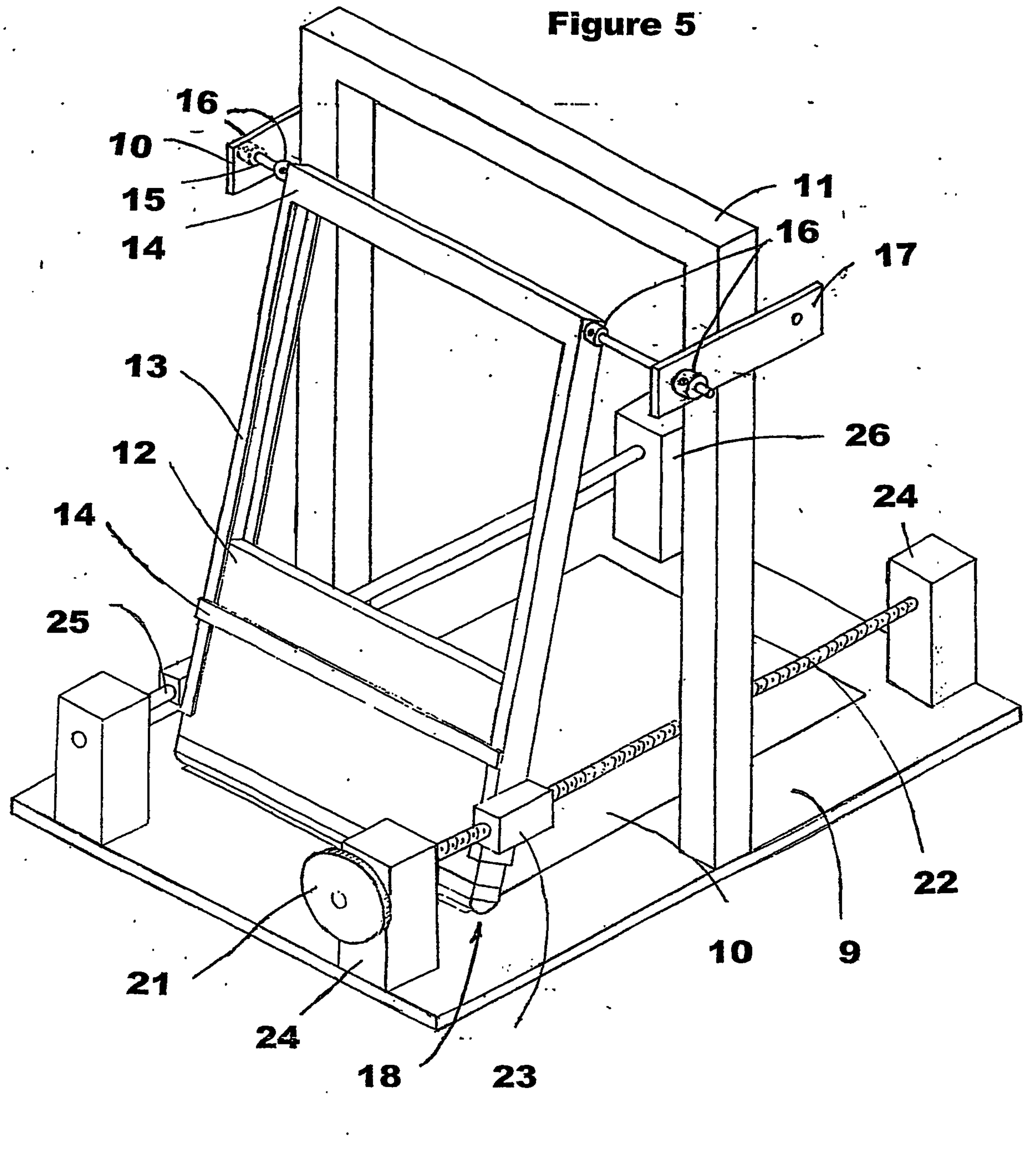


Figure 4

Figure 5



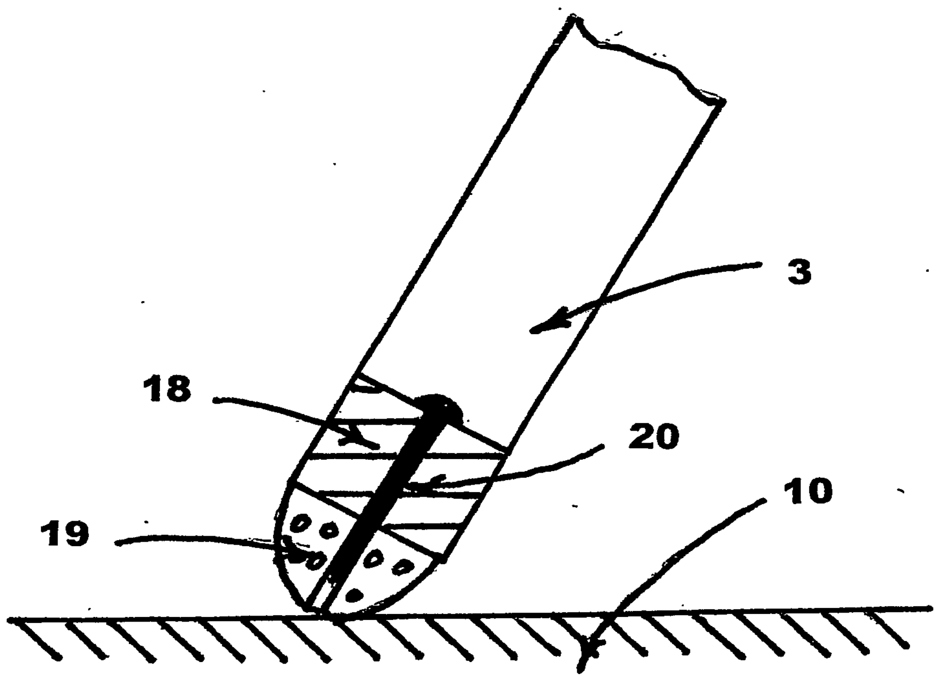


Figure 6

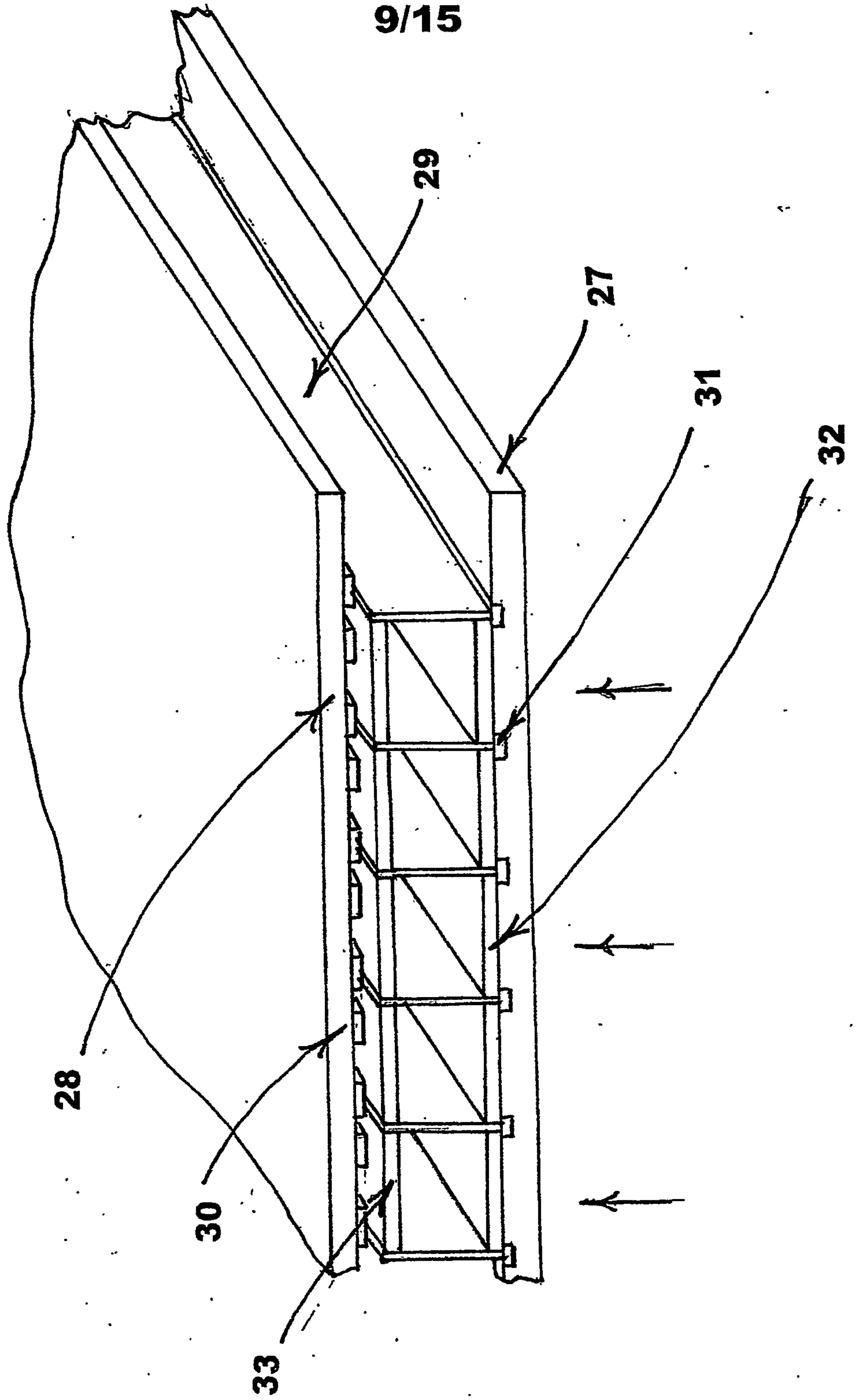


Figure 7

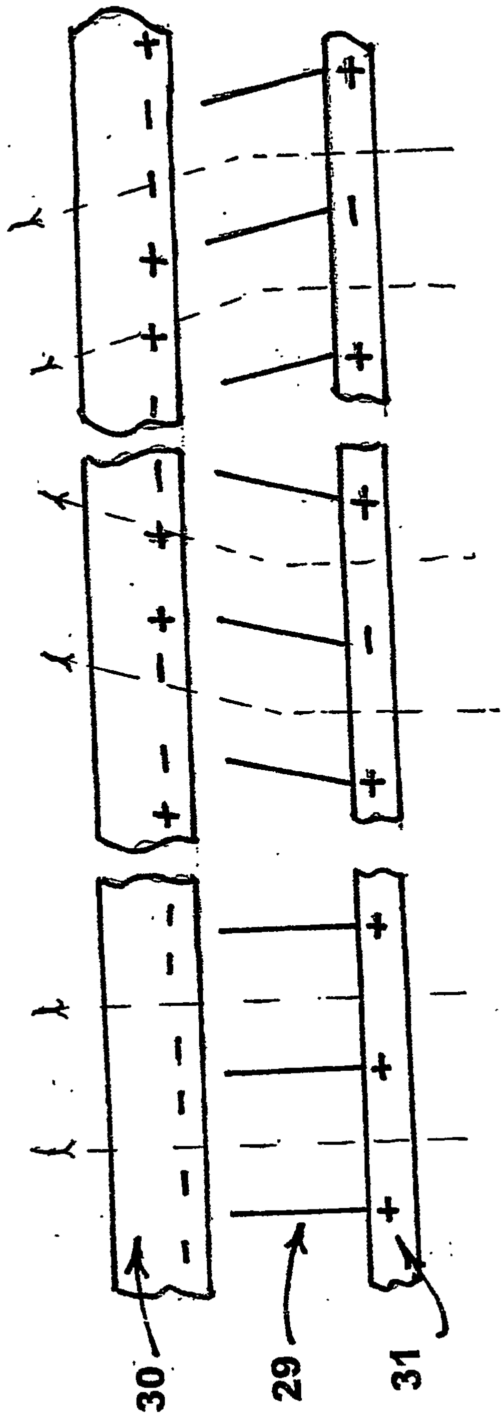


Figure 8

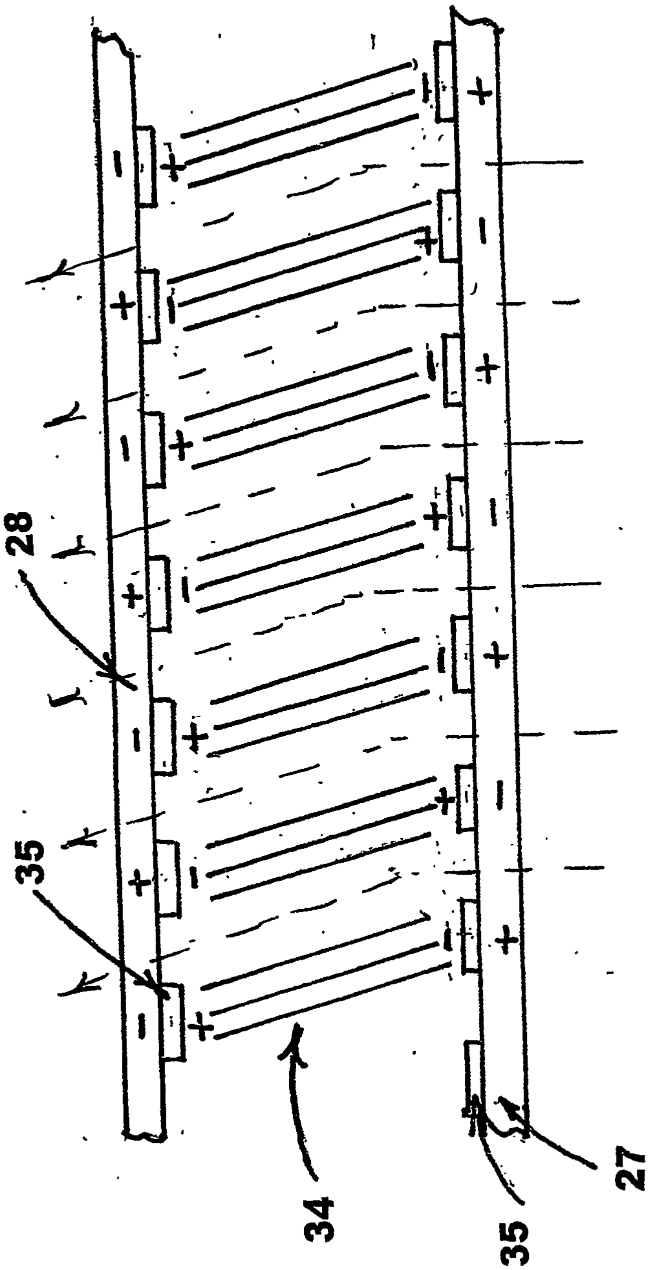


Figure 9

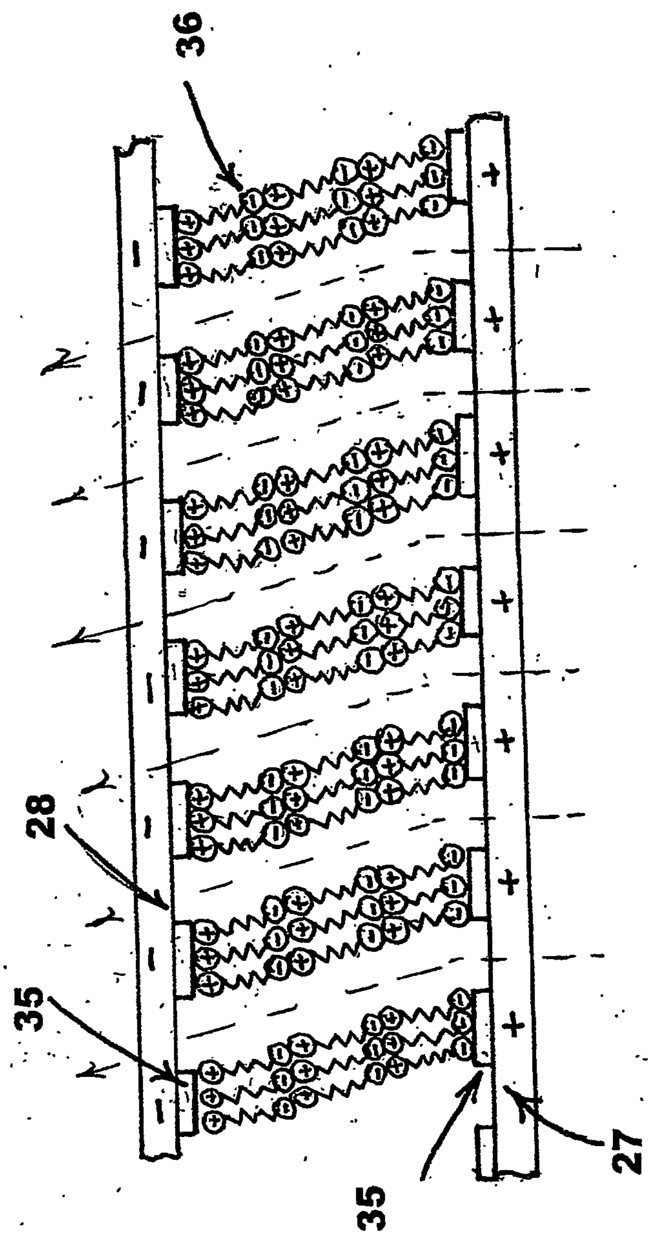


Figure 10

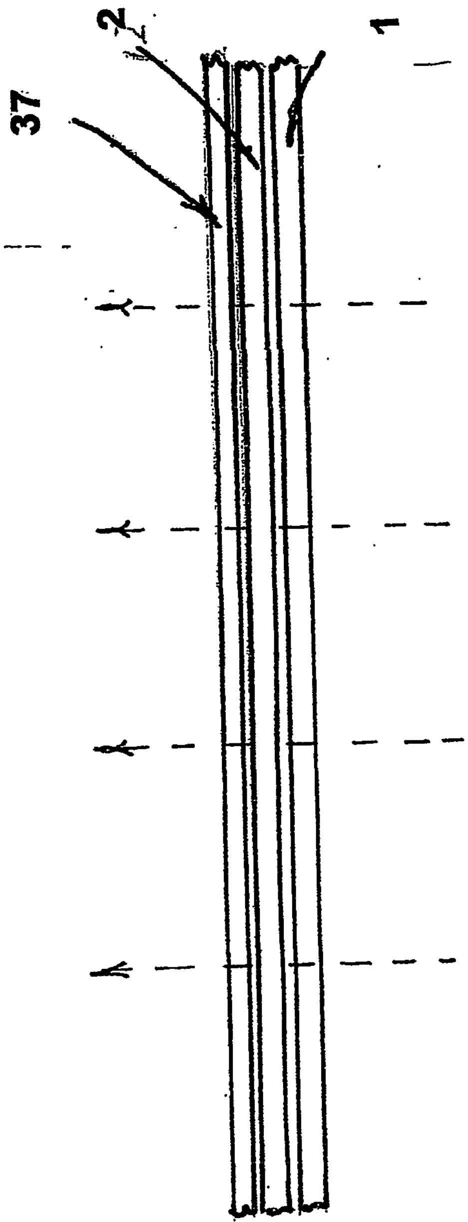


Figure 11

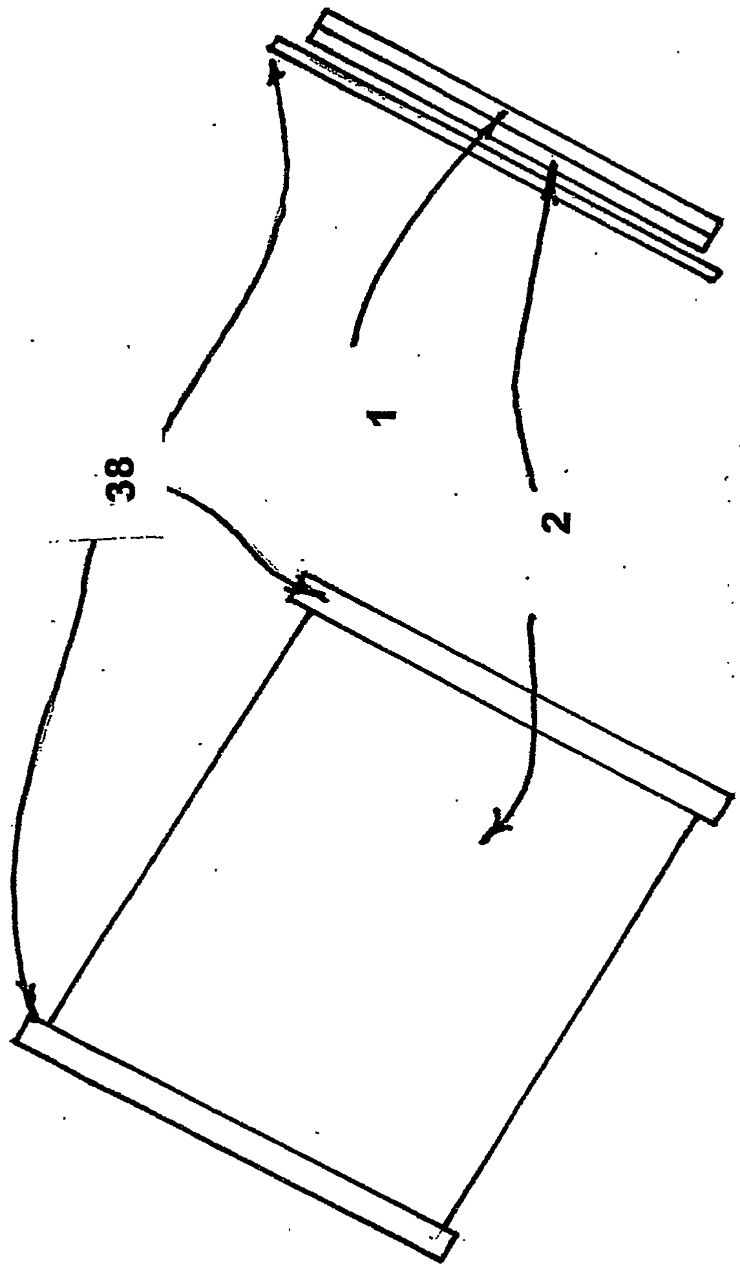


Figure 12

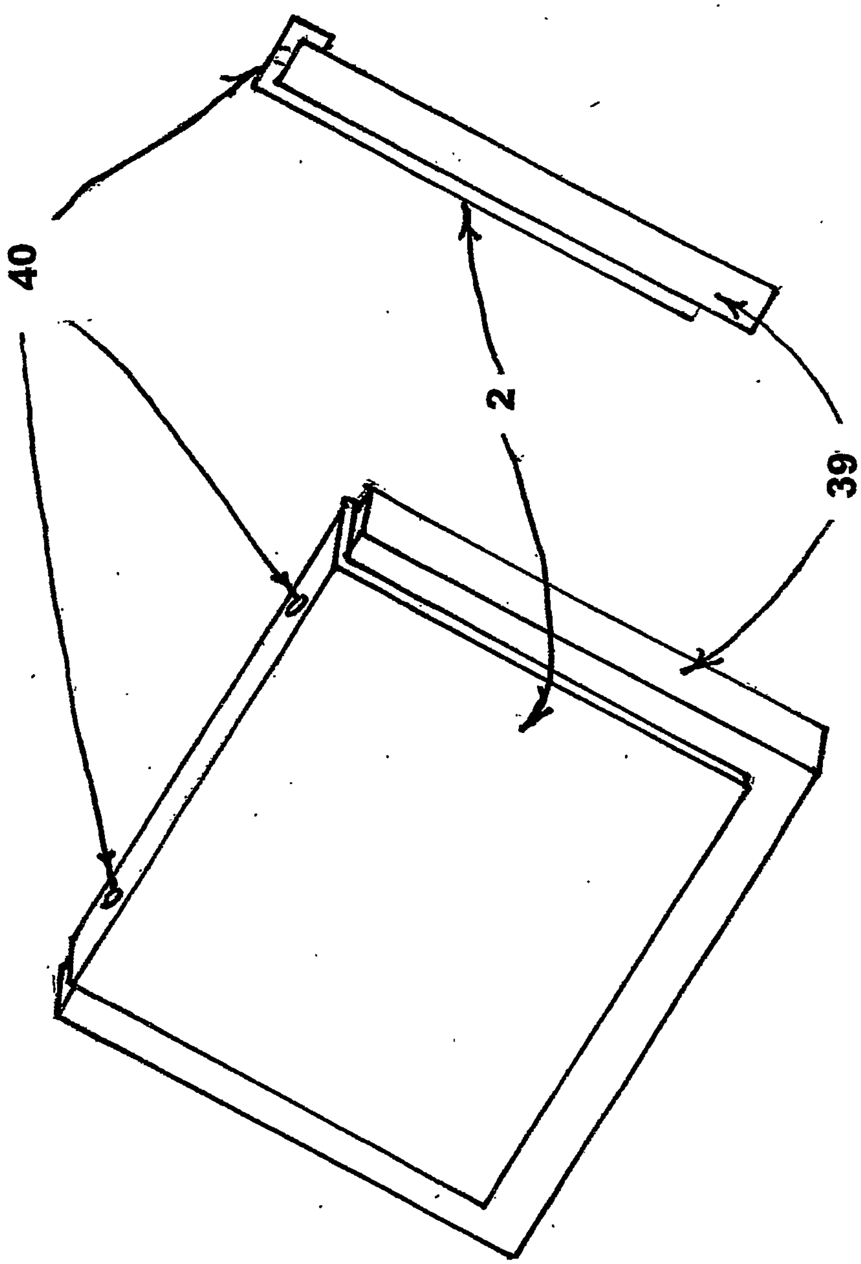


Figure 13